

Validation of ECMWF global forecast model parameters using GLAS atmospheric channel measurements

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[1] Satellite lidar (LIght Detection And Ranging) data from GLAS is used to ascertain the performance of the European Center for Medium Range Weather Forecasts model predictions of cloud fraction, cloud vertical distribution, and boundary layer height. Results show that the model is reasonably accurate for low and middle clouds, but often misses the location and amount of high cirrus clouds. The model tends to overestimate high cloud fraction and this error grows with forecast length. The GLAS-derived boundary layer height over the oceans is generally 200–400 m higher than the model predictions, but small-scale and global patterns of PBL height show similar features. **Citation:** Palm, S. P., A. Benedetti, and J. Spinhirne (2005), Validation of ECMWF global forecast model parameters using GLAS atmospheric channel measurements, *Geophys. Res. Lett.*, 32, L22S09, doi:10.1029/2005GL023535.

1. Introduction

[2] In January 2003 the Geoscience Laser Altimeter System (GLAS) was launched into a near-polar orbit aboard the Ice Cloud and land Elevation Satellite (ICESat) [Zwally *et al.*, 2002]. In addition to a high resolution 1064 nm altimetry channel, GLAS contains both 1064 and 532 nm atmospheric backscatter lidar channels. The 532 nm atmospheric channel has been operating since September 25, 2003 providing unprecedented views of the vertical structure of atmospheric aerosol, cloud layers and the depth and structure of the planetary boundary layer (PBL) [Spinhirne *et al.*, 2005]. The high vertical (76 m) and horizontal (175 m) resolution of the GLAS data provide accurate measurements of cloud height and vertical structure, tropopause height and Planetary Boundary Layer (PBL) height. These measurements constitute a valuable data set for the validation of global weather forecast and climate models. Clouds play an integral role in the climate system, primarily through their role as modulators of radiative transfer and their contribution to diabatic heating. The accurate representation of clouds in these models is, therefore, extremely important. However, it is difficult, if not impossible, to verify its forecasts of cloud extent and coverage, especially in the vertical. Similarly, PBL height is an important model parameter that is difficult to validate due to a lack of global observations.

[3] GLAS represents a unique opportunity to verify cloud field forecasts of various models such as the European

Center for Medium-range Weather Forecasts (ECMWF) forecast model. Using an approach similar to the method presented here, Miller *et al.* [1999] validated ECMWF model output of cloud height and coverage using limited data from the shuttle Lidar In-space Technology Experiment (LITE). Randall *et al.* [1998] compared boundary layer height derived from the LITE data with output from the Colorado State University atmospheric general circulation model as well as the National Center for Atmospheric Research (NCAR) Community Climate Model 3 (CCM3). In this paper we demonstrate the utility of GLAS data for the verification of global ECMWF output fields of cloud height, fraction and PBL height. As orbiting lidar data from the ICESat Mission, CALIPSO [Winker *et al.*, 2003] and The Earth Explorer Atmospheric Dynamics Mission (ADM-Aeolus) [Duran *et al.*, 2004] and those to follow become commonplace, the value for not only model validation but also for data assimilation will greatly increase.

2. Data and Methodology

[4] The ECMWF spectral model contains a sophisticated cloud scheme that is highly regarded within the scientific community [Jakob, 2003]. It uses triangular truncation at wave number 511 (roughly 40 km resolution) and has 60 model levels in the vertical. This is a slight increase in resolution compared to the version of the ECMWF model used by Miller *et al.* [1999] in their analyses (60 × 60 km horizontal with 31 vertical levels). The GLAS data utilized for this study are the vertical cross-sections of calibrated attenuated backscatter along the ICESat ground track (GLA07) [Spinhirne *et al.*, 2005]. The 5 Hz data were first averaged to a 5 second horizontal resolution (35 km), and the 5s orbital position data were then supplied to ECMWF for a number of ICESat orbits. ECMWF 6 and 48 hour global forecasts were run such that the verification times are within 3 hours of the given ICESat orbit. The ECMWF forecast fields were extracted from the output grid box that intersects with the ICESat orbit. The ECMWF data consist of vertical profiles of the prognostic fields at each of 60 model pressure levels ranging from the surface to the 0.1 mb level, where each pressure surface corresponds to a specific geometric height. Linear interpolation was then used to vertically interpolate the ECMWF cloud fraction from the model levels to the vertical grid defined by the GLAS data (every 76 m) starting at sea level and extending to an altitude of 20 km. After this process is completed, the two data sets are vertically aligned and can be compared in a number of ways. Note that in the analysis presented here, no consideration is being made for the fact that we are comparing a thin cross-section through the atmosphere with

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